High p_T Azimuthal Asymmetry in Non-central A+A at RHIC [*]

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In order to interpret data on nuclear collisions from recent Relativistic Heavy Ion Collider (RHIC) experiments, it is obviously necessary to have knowledge of the *initial conditions*. Currently, there is an order of magnitude uncertainty in the initial produced gluon density, $\rho_g(\tau_0) \sim 10 - 100/\mathrm{fm}^3$, in central $Au + Au$ at $\sqrt{s} = 130$ AGeV since widely different models are consistent with PHOBOS data. We note that recent PHENIX data appear to be inconsistent with at least one class (final state) of gluon saturation models. It is essential, however, to check this with other observables as well. High p_T observables are ideally suited for this task because they provide a measure of the total energy loss, ΔE, of fast partons, resulting from medium induced non-abelian radiation along their path. For intermediate jet energies ($E < 20$ GeV), the predicted gluon energy loss in a *static* plasma of density ρ_g and thickness, L is approximately $\Delta E_{GLV} \sim E(L/6 \ \mathrm{fm})^2 \rho_g/(10/\mathrm{fm}^3)$. The approximate linear dependence of ΔE on ρ_g is the key that enables high p_T observables to convey information about the initial conditions. However, ΔE also depends non-linearly on the geometry, L, of the plasma and therefore differential observables which have well controlled geometric dependences are also highly desirable.

A new way to probe ΔE in variable geometries was recently proposed in Ref.[1]. The idea is to exploit the spatial azimuthal asymmetry of non-central nuclear collisions. The dependence of ΔE on the path length $L(\phi)$ naturally results in a pattern of azimuthal asymmetry of high p_T hadrons which can be measured via the differential elliptic flow parameter (second Fourier coefficient), $v_2(p_T)$. In this paper, we predict $v_2(p_T > 2 \text{ GeV})$ for two models of initial conditions which differ by an order of magnitude. We first generalize the finite energy GLV theory to take into account the expansion (neglected in [1]) of the produced gluon-dominated plasma while retaining kinematic constraints important for intermediate jet energies. We show that the combined pattern of jet quenching in the single inclusive spectra and the differential elliptic flow

at high p_T provide complementary tools that can determine the density as well as the spatial distribution of the quark-gluon plasma created at RHIC.

Fig. 1 shows the predicted pattern of high p_T anisotropy. Note the difference between sharp cylinder and diffuse Wood-Saxon geometries at $\mathbf{b} = 7$ fm, the characteristic impact parameter of minimum bias events. While the central ($\mathbf{b} = 0$) inclusive quenching is insensitive to the density profile, non-central events clearly exhibit large sensitivity to the actual distribution.
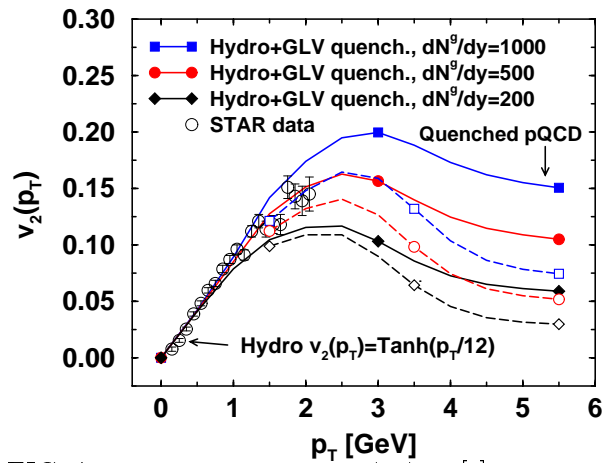

FIG. 1. The interpolation of $v_2(p_T)$ between the soft hydrodynamic and hard pQCD regimes is shown for $b = 7$ fm.

We conclude that $v_2(p_T > 2 \text{ GeV}, \mathbf{b})$ provides essential complementary information about the geometry and impact parameter dependence of the initial conditions in $A + A$. In particular, the rate at which the v_2 coefficient decreases at high p_T is an indicator of the diffuseness of that geometry.

Footnotes and References

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[†][1] X.-N. Wang, nucl-th/0009019